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Title:	SYSTEM AND METHOD FOR INSURING DYNAMIC HOST CONFIGURATION PROTOCOL OPERATION BY A HOST CONNECTED TO A DATA NETWORK
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SYSTEM AND METHOD FOR INSURING DYNAMIC HOST CONFIGURATION PROTOCOL OPERATION BY A HOST CONNECTED TO A DATA NETWORK

BACKGROUND OF THE INVENTION

A. Field of the Invention

The present invention relates to the field of network communications and, more particularly, with the configuration of network devices in a data network.

B. Description of Related Art

Cable television service providers are taking advantage of the extensive reach of the cable network infrastructure to offer high-speed data network access to users of computing equipment, such as personal computers. Channels on the cable television network may be allocated for use as data network access channels to exploit channel bandwidths of 6 MHz on a medium having a frequency range of up to 1 GHz.

Subscribers of cable service may access data network services by connecting computers to the cable network using cable modems. Subscribers may also access data networks via one or more cable modems connected on a local area network. A cable modem has a radio interface connection to a broadband coaxial cable infrastructure and a data interface connection to the computer, or to a computer network. When used to connect a computer to the cable network, the cable modem may operate internal to the computer in a card slot with a direct connection to the bus system in the computer. The cable modem may also operate external to the computer with an external connection (*e.g.* Ethernet, serial, etc.) to the cable modem data interface.

Data networks connected to a cable network form what are called Data Over Cable Systems. Data over cable systems use a device called a cable modem termination system as an intermediary between a number of cable modems connected over the coaxial communications medium and a data network. The data network may also include a connection to the Internet. The cable modem termination system operates along with other system components in a "head-end" of the cable network. A cable service provider uses the cable modem termination system to distribute services to the cable modems

connected to it. The cable modem termination system also provides facilities that may be used to manage the resources available to the cable modems.

Cable modems may operate on a bi-directional cable system or on a uni-directional cable system. In a bi-directional cable system, the cable modems may communicate with the cable modem termination system over the coaxial medium in both directions. That is, the cable modems may transmit and receive data to and from the cable modem termination system over the coaxial medium.

In an uni-directional cable system, data is communicated over the coaxial medium in a "downstream" direction only. That is, the cable modem may only receive data from the head-end of the cable network over the coaxial medium. The cable modem may transmit data in the "upstream" direction to the head-end of the cable network using an alternative communications device; such as by a telephone connection over the public switched telephone network (PSTN). Because cable networks have been traditionally used as a broadcast medium for cable television, most data over cable systems are still uni-directional systems.

Uni-directional and bi-directional data over cable systems perform a procedure for configuring the cable modems to connect to a data network. The Dynamic Host Configuration Protocol (DHCP) is used by devices that are connected to networks, such as the Internet, to obtain configuration parameters and other information that make it possible for the devices to communicate on the Internet. The devices perform the DHCP protocol as clients that query a DHCP server during the initialization procedure performed by the device at boot up. Once the DHCP server responds with the appropriate parameters, the devices may begin to communicate by sending and receiving packets on the Internet. The DHCP may be used by client computers and by cable modems that are connected to a data over cable system.

The parameters that a device may obtain using the DHCP include an Internet Protocol address (IP address), a list of domain name servers, a domain name, the lease time of the IP address, a default gateway for the device, a trivial file transfer protocol (TFTP) server address and TFTP file name. The DHCP has been adopted by the industry as a standard protocol that is documented in RFC 2131. The RFC 2131 describes the

many parameters that may be obtained from the DHCP server. The RFC 2131 also describes instructions for communicating with the DHCP server. In a data over cable system, client computers and cable modems each use configuration parameters from a DHCP server before communicating on a data network. The cable modems obtain parameters during the initialization and registration process. The client computers may also obtain configuration parameters during system initialization.

The client computer uses the cable modem to access the data network, and thus, to access the DHCP server. However, until the cable modem is properly initialized, registered and fully connected, it cannot perform communications functions for the client computer or computers to which it is connected. This may cause problems for client computers in a variety of scenarios. For example, a computer may attempt to use a bi-directional cable modem to issue DHCP messages before the RF cable has been connected to the cable modem. In addition, if the cable modem and the computer are on the same power strip or if an internal cable modem is used and powered by the computer's bus system, the two always power-up simultaneously. If it takes more time for the cable modem to power-up and to become initialized and registered than for the computers to perform DHCP messages, the DHCP messages will not be communicated. In such situations, the connection may become permanently shut down.

Moreover, any client computer that obtains configuration parameters from a DHCP server connected to a data network to which it accesses via a communications device, such as a modem, or a gateway, may experience the same difficulty. If the communications device takes more time to initialize than it takes the client computer to begin requesting configuration parameters, the client computer may not be able to access configuration parameters from the DHCP server. Because a failure to retrieve configuration parameters is typically treated as an error, the client computer may require a restart to begin another request for configuration parameters. Where the communications device is connected to the client computer system bus, the communications device is reset whenever the client computer is reset. The client computer may never obtain configuration parameters in such a scenario permanently shutting down its connection to the data network.

It would be desirable to ensure DHCP operation on a client computer without the risk of permanently losing the connection through the communications device if the communications device is also not yet ready or able to perform DHCP messages from the client to the server.

It would be desirable to ensure DHCP operation on a client computer without the risk of losing the connection through the cable modem permanently if the cable modem is not yet ready or able to perform DHCP messages from the client to the server.

SUMMARY OF THE INVENTION

In view of the above, according to one aspect of the present invention an improved communication system comprising a customer premises equipment connected to a data network via a network connection is provided. The customer premises equipment communicates with the data network when configured with a client network address. The customer premises equipment issues configuration messages to a configuration server connected to the data network to retrieve the client network address from the configuration server. The improvement includes a temporary configuration server for responding to configuration messages from the customer premises equipment before the network connection is capable of connecting the customer premises equipment to the data network.

In a further aspect of the present invention, a cable modem is provided for providing a customer premises equipment with access to a configuration protocol server connected to a data network over a broadband coaxial cable medium. The data network includes an interface to the broadband coaxial medium at a head-end of the broadband coaxial medium. The cable modem includes a cable input/output interface for communicably connecting the cable modem to the broadband coaxial cable medium. A data input/output interface is provided to communicably connect the cable modem to the customer premises equipment. A temporary configuration protocol server is included to respond to configuration messages from the customer premises equipment before the cable modem is capable of connecting the customer premises equipment to the data network.

In a further aspect of the present invention, a method is provided for ensuring a connection to a configuration server on a data network by a customer premises equipment. The customer premises equipment is connected to a network connection for interfacing to the data network. According to the method a request is issued for a customer premises equipment network address from the customer premises equipment to the configuration protocol server via the network connection. The network connection determines whether a connection can be made to the configuration protocol server. If not,

the network connection responds to the customer premises equipment by sending a temporary network address to the customer premises equipment.

BRIEF DESCRIPTION OF THE DRAWINGS

Presently preferred embodiments of the invention are described below in conjunction with the appended drawing FIGs., wherein like reference numerals refer to like elements in the various FIGs., and wherein:

FIG. 1 is a block diagram of a network of the type in which the present invention finds particular use;

FIG. 2 is a block diagram of the network in FIG. 1 in a data over cable network system;

FIG. 3 is a customer premises equipment that uses the DHCP to obtain configuration parameters in the network shown in FIG. 1;

FIG. 4A-E are block diagrams showing the status of the customer premises equipment and the flow of DHCP messages used during the negotiation of configuration parameters with the DHCP.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The description that follows fully incorporates by reference the following co-pending patent applications: "METHOD AND SYSTEM FOR SECURE CABLE MODEM INITIALIZATION", U.S. Patent Ser. No. 09/018,756 to Nurettin B. Beser (filed February 4, 1998 and assigned to the assignee of the present invention); "METHOD AND SYSTEM FOR SECURE CABLE MODEM REGISTRATION", U.S. Patent Ser. No. 09/018,372 to Nurettin B. Beser (filed May 14, 1998 and assigned to the assignee of the present invention); and "METHOD AND SYSTEM FOR CABLE MODEM INITIALIZATION USING DYNAMIC SERVERS", U.S. Patent Ser. No. 09/018,400 to Nurettin B. Beser (filed May 14, 1998).

FIG. 1 is a block diagram showing a system that may be used by a customer premises equipment **18a** to retrieve configuration parameters from a configuration server **50** for communicating over a data network **28**. The customer premises equipment **18a** communicates with the data network **28** over a network connection **13** as a host to the configuration server **50**. The network connection **13** may include a local network **14** over which the customer premises equipment communicates with other customer premises equipment **18b-d**. The network connection **13** may also include communications devices **15a-d** that connect corresponding customer premises equipment **18a-d** to the local network **14**. A network interconnection device **17** connects the local network **14** to the data network **28**.

The communications devices **15a-d** may include any device for communicably connecting the corresponding customer premises equipment **18a-d** to the local network **14**. A suitable communications device is selected according to the type of network used for the local network **14**. For example, the communications devices **15a-d** may include cable modems when the local network **14** is a cable network. For another example, the communications devices **15a-d** may include serial modems for when the local network **14** is a general switched telephone network. For yet another example, the communications devices **15a-d** may include network interface adapters when the local network **14** is a network communicating with ethernet, token ring, etc. The communications devices **15a-d** may also include a combination of devices, such as a telephony return cable modem

with a serial connection to the general switched telephone network and a coaxial connection for connection to the cable network. The communications devices **15a-d** may or may not require configuration parameters to enable communication between the customer premises equipment **18a-d** and the data network **28**.

The network interconnection device **17** may include any server, gateway, bridge, router or other type network device for connecting one network to another network. The network interconnection device **17** connects the local network **14** to the data network **28**. Appropriate protocol stacks are included in the network interconnection device **17** to ensure that the local network **14** can communicate with the data network **28**. One protocol included in such protocol stacks may include a configuration protocol to permit the network interconnection device **17** to retrieve configuration parameters from the configuration server **50**.

The network interconnection device **17**, the local network **14** and the communications devices **15a-d** provide the customer premises equipment **18a-d** with the network connection **13** to the data network **28**. Selected network communications protocols are performed by the components of the network connection **13** and the customer premises equipment **18a-d** to provide extensive connectivity and functional capability. Specific embodiments of the network connection **13** exist and depend on the types of networks implemented for the local network **14** and the communications devices **15a-d**. In one embodiment, the local network **14** is a cable network and the communications devices **15a-d** are cable modems that provide the customer premises equipment **18a-d** with access to the data network **28** through the cable network. The cable network may be bi-directional or uni-directional. In the uni-directional network, the local network **14** may include a general switched telephone network and the cable network.

In an alternative embodiment, the local network **14** may comprise an ethernet network, or other network type such as a token ring, a Universal Serial Bus, etc. The communications devices **15a-d** include appropriate network adapters for communicating over the local network **14**. The network adapters may be installed in a chassis for a bus system in the customer premises equipment **18a-d**. The network interconnection device

17 includes a data over cable system in which a cable modem is communicably connected to the local network **14**. The cable modem provides all of the customer premises equipment **18a-d** with shared access to the data network **28**. The cable modem in the network interconnection device **17** is connected to a cable network. The cable network is connected to a cable modem termination system, which provides the cable modem with access to the data network **28**. The cable modem in such an embodiment may require configuration parameters from the configuration server **50**.

The customer premises equipment **18a-d** may include any type of computer, or device that uses computing resources, that may communicate with the data network **28**. The customer premises equipment **18a-d** are clients of the configuration server **50** from which it retrieves configuration parameters during initialization. The customer premises equipment **18a-d** use the configuration parameters to communicate over the data network **28**. Such parameters may include network addresses without which the communication over the data network **28** beyond broadcast searches for a server may not be possible.

The data network **28** in a preferred embodiment is connected to the Internet. The configuration server **50** in a preferred embodiment is the dynamic host configuration protocol (DHCP) server. One of ordinary skill in the art will appreciate that any data network **28** and any configuration server **50** operable to perform a configuration protocol that is compatible with the data network **28** may be used.

Embodiments of the present invention advantageously permit the customer premises equipment **18a-d** to initialize in cases in which an operable network connection to the configuration server **50** may be unavailable. In a preferred embodiment, a temporary configuration server operates in the communications device **15a** or in the network interconnection device **17** to provide temporary configuration parameters to the customer premises equipment **18**. The configuration parameters are provided with a mechanism for requiring further requests for configuration parameters at a later time. For example, in a preferred embodiment, the temporary configuration parameters are provided with a lease time. Upon expiration of the lease time, the customer premises equipment **18** is required to make another request for configuration parameters. At this time, the temporary configuration server determines if an operable connection to the

configuration server **50** is possible. If it is not, the configuration server provides the same configuration parameters and lease time. If the connection is available, the temporary configuration server permits the request to be communicated to the configuration server **50**.

A data over cable network system is one example of a network in which embodiments of the present invention may find advantageous use. FIG. 2 is a block diagram showing a data over cable network **10**. It is to be understood by one of skill in the art that the data over cable network **10** is described as an example. The data over cable system used in the present invention may be configured in other ways not shown here.

Most cable providers known in the art predominately provide uni-directional cable systems, supporting only a "downstream" data path. A downstream data path is the flow of data from a cable television network "headend" to customer premise equipment (e.g., a customer's personal computer). A cable television network headend is a central location that is responsible for sending cable signals in a downstream direction. A return path via a telephony network ("telephony return") is typically used for an "upstream" data path in uni-directional cable systems. An upstream data path is the flow of data from customer premise equipment back to the cable television network headend.

However, data-over-cable system **10** may also provide a bi-directional data path (i.e., both downstream and upstream) without telephony return as is also illustrated in FIG. 2. In a data-over cable system without telephony return, customer premise equipment or cable modem has an upstream connection to the cable modem termination system via a cable television connection, a wireless connection, a satellite connection, or a connection via other technologies to send data upstream to the cable modem termination system.

The data over cable network **10** provides network access for a customer premises equipment (CPE) **18** via a cable modem network **14**. The cable modem network **14** is connected to a data network **28** (e.g., an Internet subnet, an intranet, or any network that uses the transport control protocol/Internet protocol (TCP/IP)) by a cable modem termination system **12**. The CPEs **18** may include DHCP clients for retrieving

configuration parameters from a DHCP server **50**. The CPE **18** may also retrieve configuration files from a trivial file transfer protocol server **51**.

The CPE **18** in the network **10** of FIG. 2 may be a personal computer or workstation that uses the Windows NT, Windows 95 or later versions of Windows as an operating system. It is to be understood that any CPE using any operating system may be used in the CPE **18**. The CPE **18** may include architecture for interfacing to communication devices. Such architecture advantageously standardizes communications interfaces and reduces the development time of application that uses communications interfaces.

The CPE **18** includes a cable modem to CPE connection **19**, a cable modem-CPE interface (CMCI) **20**, and a cable modem (CM) **16**. The cable modem to CPE connection **19** may include a connection to the CPE bus if the cable modem **16** is implemented on a card, or circuit board, that plugs into the CPE bus structure. Alternatively, the cable modem **16** may be physically external to the CPE and connected by the cable modem to CPE connection **19** using an Ethernet network, token ring network, a serial connection, or any other suitable hardware connection.

The cable modem-CPE interface **20** includes the Windows Network Architecture and any drivers for controlling the hardware interface of the cable modem **16**. The cable modem-CPE interface **20** includes any hardware drivers, protocol drivers and other hardware and software used to communicate with the cable modem **16**.

In a uni-directional system, the cable modem **16** is connected to the cable modem network **14** which may include cable television networks such as those provided by Comcast Cable Communications Inc. of Philadelphia, Pennsylvania, Cox Communications, of Atlanta, Georgia, Tele-Communications, Inc. of Englewood, Colorado, Time-Warner Cable, of Marietta, Georgia, Continental Cable Vision, Inc. of Boston, Massachusetts and others.

The cable modem **16** is connected to a Public Switched Telephone Network ("PSTN") **22** with an upstream telephony connection. The PSTN **22** includes those public switched telephone networks provided by AT&T, Regional Bell Operating Companies (e.g., Ameritch, U.S. West, Bell Atlantic, Southern Bell Communications,

Bell South, NYNEX, and Pacific Telesis Group), GTE, and others. The upstream telephony connection is any of a standard telephone line connection, Integrated Services Digital Network ("ISDN") connection, Asymmetric Digital Subscriber Line ("ADSL") connection, or other telephony connection. The PSTN **22** is connected to a Telephony Remote Access Concentrator ("TRAC") **24**.

In a data-over cable system without telephony return, the cable modem **16** has an upstream connection to CMTS **12** via the cable network **14**, a wireless connection, a satellite connection, or a connection via other technologies to send data upstream outside of the telephony return path. An upstream cable television connection via cable network **14** is illustrated in FIG. 2.

The cable modem **16** includes cable modems provided by the 3Com Corporation of Santa Clara, California and others. The cable modem **16** may also include functionality to connect only to the cable network **14** and receives downstream signals from cable network **14** and sends upstream signals to cable network **14** without telephony return. The present invention is not limited to cable modems used with telephony return.

The cable modem **16** in FIG. 2 includes a computing platform that controls the communications functions performed by the cable modem **16**. For example, the cable modem **16** may implement a variety of communications protocols. To implement one such protocol, the DHCP, the cable modem **16** includes a DHCP client for sending requests for configuration parameters to the DHCP server **50**. Once the cable modem **16** receives configuration parameters, the CPE **18** can use the cable modem **16** to communicate with the data network **28**.

In preferred embodiments of the present invention, the cable modem **16** also includes a temporary DHCP server for responding to DHCP requests from the CPE **18** while the cable modem **16** is in the process of connecting to the data network. Until the cable modem **16** is initialized including being assigned an IP address, it cannot communicate over the data network. Until the cable modem **16** is able to communicate over the data network **38**, the CPE **18** is unable to request DHCP configuration parameters. In a preferred embodiment, the temporary DHCP server determines if the cable modem **16** is able to communicate over the data network **28**. If the CPE **18** requests

configuration parameters using DHCP and the cable modem **16** is unable to communicate over the data network **28,** the temporary DHCP server replies with a temporary IP address. The temporary DHCP server may also provide a selected lease time to the CPE **18**. The lease time insures that the CPE **18** will continue to request the IP address. The temporary DHCP server senses when the cable modem **16** is able to communicate over the data network **28** and responds to future requests for the IP address with a DHCP NACK message. The CPE **18** then makes a DHCP DISCOVER, which the cable modem **16** communicates to a DHCP server in the data network **28** instead of to the temporary DHCP server.

The cable modem **16** provides the CPE **18** with connectivity to the data network **28** via the CMTS **12** and the TRAC **24**. The CMTS **12** and TRAC **24** may be at a "headend" of the cable system **10**, or TRAC **24** may be located elsewhere and have routing associations to CMTS **12**. The CMTS **12** and TRAC **24** together are called a "Telephony Return Termination System" ("TRTS") **26**. The TRTS **26** is illustrated by a dashed box in FIG. 2. The CMTS **12** and TRAC **24** make up TRTS **26** whether or not they are located at the headend of cable network **14**, and TRAC **24** may in located in a different geographic location from CMTS **12**. Content severs, operations servers, administrative servers and maintenance servers, shown as servers **31**, may be used in data-over-cable system **10**. The servers **31** may be in various locations.

Access points to data-over-cable system **10** are connected to one or more CMTS's **12** or cable headend access points. Such configurations may be "one-to-one", "one-to-many," or "many-to-many," and may be interconnected to other Local Area Networks ("LANs") or Wide Area Networks ("WANs").

The TRAC **24** is connected to the data network **28** by a TRAC-Network System Interface **30** ("TRAC-NSI"). The CMTS **12** is connected to data network **28** by a CMTS-Network System Interface ("CMTS-NSI") **32**. The present invention is not limited to data-over-cable system **10** illustrated in FIG. 2, and more or fewer components, connections and interfaces could also be used. In addition, the present invention may include any type of network that uses the DHCP server for configuration parameters and that runs using any operating system.

The DHCP server **50** and the TFTP server **51** may operate on any computer that is accessible to the cable modem **16** over the data network **28**. Alternatively, the DHCP server **50** may be accessible over a local area network. The DHCP server **50** and the TFTP server **51** will provide configuration services for any DHCP client that may connect to it over the data network **28**. For example, in the cable system **10** shown in FIG. 2, the DHCP server **50** may provide configuration services for the cable modem **16**, any other cable modem connected to the cable network **14** and/or any network device connected to the data network **28**.

FIG. 3 is a block diagram of the CPE **18** showing the CPE to cable modem interface **20** according to a preferred embodiment of present invention. The CPE **18** in FIG. 3 uses the cable modem **16** to connect to the data network **28**. The CPE **18** is preferably a computing platform functioning as a workstation, personal computer, server or other computing system that may connect to the data network **28**. The CPE **18** includes a system initialization procedure **80**, a DHCP client **100**, and an Internet protocol (IP) stack **120**. The CPE **18** and the cable modem **16** retrieve configuration parameters from the DHCP server **50**.

The system initialization procedure **80** is performed on power-up or on any other re-initialization of the CPE system. One function of the system initialization procedure **80** is to initialize the hardware drivers used by the CPE to perform communications functions. With regards to communication over the data network **28**, the CPE **18** initializes a driver for the cable modem **16** (described below) and attempts to broadcast requests for configuration parameters. The CPE **18** requests configuration parameters from the DHCP server **50** over the data network **28** using one or more DHCP DISCOVER messages. When replies to the DHCP DISCOVER messages are received, the CPE **18** stores the configuration parameters in a memory space for client configuration parameters **194a, b**.

The DHCP client **100** performs DHCP operations for the CPE **18**. The DHCP DISCOVER message and messages sent in response to DHCP parameter negotiation (*e.g.* DHCP REQUEST, DHCP OFFER, etc.). The DHCP client **100** may also sense when the lease time for an IP address has expired, or may respond with a request to renew the IP

address by issuing a DHCP RENEW message. The operation of the DHCP client **100** is preferably in conformance with the provisions of RFC 2131.

The DHCP server **50**, as shown in FIG. 3, provides a client IP address **196a** to the CPE **18**, and a cable modem IP address **196b** to the cable modem **16**. Although one DHCP server **50** is shown in FIG. 3, one of ordinary skill in the art will appreciate that DHCP messages may be handled by different DHCP servers, or by selected DHCP servers. The operation of the DHCP server **50** is preferably in conformance with the provisions of RFC 2131.

The IP stack **120** includes protocol drivers conforming to selected protocols for communicating with the data network **28** and to any other network to which a data connection is desired (*i.e.* the Internet). The protocols performed by the IP stack **120** may include the Universal Datagram Protocol (UDP), the Internet Protocol (IP), the transport control protocol (TCP), the point-to-point protocol (PPP), and any other protocol required for selected data network connections. The protocols selected for the IP stack **120** include a protocol having driver calls software that communicates to the cable modem **16** in the CPE to cable modem interface **20**.

The CPE to cable modem interface **20** includes a cable modem driver **160** and the hardware and software components used to connect the cable modem **16** to the CPE **18**. Such components may include the bus or other type of interconnect system and the drivers that control communications on the bus system. For example, the cable modem **16** may be implemented on a PCMCIA (Personal Computer Memory Card International Association) card that interfaces with the CPE **18** using the PCMCIA bus system. The cable modem **16** may also be implemented as an external device connected to the CPE **18** by an Ethernet-based local area network. The cable modem **16** may also be implemented on a card in a second CPE or server that is connected to the CPE **18** and used by the CPE **18** for access to the data network **28**. In a preferred embodiment, the connections between the IP stack **120**, the cable modem driver **160** and the cable modem **16** substantially conform to the Open System Interconnection ("OSI") model used to describe comnputer networks. Reference is made to the Multimedia Cable Network Systems ("MCNS")

Data-Over-Cable Service Interface Specifications, Radio Frequency Interface Specification, SP-RFI-102-971008, (hereinafter "MCNS standard),which is incorporated herein by reference, for implementing the IP stack **120**, the cable modem driver **160** and the cable modem **16** according to a preferred embodiment. The cable modem driver **160** executes communications commands for using the cable modem **16** to communicate over the cable network **14** to other devices on the data network, such as the DHCP server **50**. In a Microsoft Windows operating system environment, the cable modem driver **160** may be developed using the Network Driver Interface Specification (NDIS) in the Windows Network Architecture. The Windows Network Architecture also includes libraries of function calls to protocol drivers, which are programs for executing the protocol performed by the IP stack **120**. The protocol drivers may be accessed using the Transport Driver Interface (TDI) which is also known as a Windows socket. Information regarding the Windows Network Architecture or any other Windows programming resource may be found in the Microsoft Windows 95 Resource Kit published by the Microsoft Press by the Microsoft Corporation.

Drivers, such as the cable modem driver **160** in a preferred embodiment, that are developed using standard development tools, such as the NDIS in Windows, typically require a uniform set of parameters defined by a standard interface. The parameters include an IP address and other parameters that may be retrieved from the DHCP server **50**.

The cable modem **16** in FIG. 3 includes hardware and software components for interfacing a data communications system (such as the CPE **18**) to the coaxial communications medium. In a preferred embodiment, the components include a DHCP server **140**, a data I/O interface **170**, a cable modem processing system **176**, a cable I/O interface **172**, and a DHCP client **190**. In the description that follows, the cable modem **16** in FIG. 3 is assumed to be a bi-directional cable modem. One of ordinary skill in the art will appreciate that preferred embodiments of the present invention may be carried out in a uni-directional system with the appropriate modifications, which are un-important to the present invention.

The data I/O interface **170** includes the hardware and software components for communicating with the CPE **18**, which may include functions performed according to the protocols described above. The cable modem **16** may receive communications from the CPE **18** at the data I/O interface **170**. The cable modem **16** may also send communications to the CPE **18** via the data I/O interface **170**. In an internal cable modem **16**, the data I/O interface **170** may include a PCI bus adapter and associated hardware drivers. In an external cable modem **16**, the data I/O interface **170** may include an Ethernet, USB, or token ring adapter and associated drivers. It is to be understood by one of ordinary skill in the art that other components may be used in the data I/O interface **170**.

The cable I/O interface **172** includes an RF interface and other hardware and software components for modulating and demodulating the RF signal and for communicating data to and from the RF interface **161**. For examples of the cable I/O interface **172** according to a preferred embodiment, reference is made to the MCNS standard. Alternative embodiments may implement an RF interface as described in the IEEE ("Institute for Electrical and Electronic Engineers") standard 802.14 for cable modems.

The cable modem processing system **176** provides processing resources for the cable modem **16**. Such resources include a central processor, memory and input/output control. The cable modem processing system **176** also includes an operating system that performs an initialization process. During the initialization process, the cable modem **16** performs initialization and registration functions by communicating initialization and registration messages to and from the headend **26** of the cable network **14**. Included in these functions is the retrieval of configuration parameters from the DHCP server **50**.

The cable modem DHCP client **190** performs the DHCP client functions for retrieving configuration parameters such as the IP address. The cable modem DHCP client **190** issues DHCP DISCOVER messages to obtain a cable modem IP address **192a** and other configuration parameters **192b**.

In a preferred embodiment of the present invention, the cable modem **16** includes a temporary DHCP server **140**. The temporary DHCP server **140** is able to detect

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whether the cable modem **16** has established a connection for communication with the headend **26**. If the cable modem **16** has yet to achieve a connection, the temporary DHCP server **140** responds to DHCP DISCOVER messages from the CPE **18** with a DHCP OFFER. The DHCP OFFER sent by the temporary DHCP server **140** includes a client temporary IP address **142a** and a lease time **142b**. Until the temporary DHCP server **140** senses that the cable modem **16** is fully connected, initialized and registered, it acknowledges requests to renew the temporary IP address **142a**.

The temporary IP address **142a** is preferably an IP address that has been reserved for this use, however, it may be any IP address that may be recognized by the cable modem **16** as being a temporary one. The temporary IP address **142a** is maintained private to the CPE **18** or to other CPE's that may be connected to the cable modem **16**. The temporary IP address **142a** is not used for connectivity to any network. The cable modem **16** filters out any attempt to communicate using the temporary IP address **142a**.

The CPE **18** is shown in FIG. 3 connected to the cable modem **16** which connects the CPE **18** to the data network **28**. In an alternative embodiment, the cable modem**16** may provide communicative connectivity for other CPE's (see FIG. 1). In such an embodiment, the temporary DHCP server **140** includes a pool of temporary IP addresses **142a**.

In addition, the lease time **142b** may be set to a short enough length of time to make the use of the temporary IP address **142a** unlikely. The lease time **142b** is preferably from 5 to 10 seconds, however, shorter or longer lease times are possible. Because the cable modem **16** may require one or more minutes to achieve connectivity, the lease time **142b** may expire, and the temporary IP address **142a** may be renewed many times before the cable modem **16** has connectivity.

In a uni-directional system, the cable modem **16** communicates upstream on a telephony link. The dialing of the telephone to initiate the link may not occur at boot up and may even require other events to trigger it. As a result, the time it takes for the cable modem **16** to achieve connectivity may vary greatly, and may be indeterminate.

Once the cable modem **16** has achieved connectivity with the headend **26**, the temporary DHCP server **140** responds to any further requests to renew the temporary IP

address **142a** with a message that does not acknowledge the request. The message that does not acknowledge the request to renew prompts the DHCP client **100** in the CPE **18** to issue a DHCP DISCOVER message to retrieve a new IP address. Because the cable modem **16** has established connectivity, the DHCP DISCOVER message is broadcast through the headend **26**. The DHCP server **50** responds with a DHCP OFFER. The DHCP server **50** may be the first DHCP server to send a DHCP OFFER, or it may be the one that offers an acceptable set of configuration parameters.

The temporary DHCP server **140** in the cable modem **16** advantageously permits the CPE **18** to "wait" for a legitimate IP address and other configuration parameters when the cable modem **16** is unable to communicate with the headend **26**.

FIGs. 4A-4E are block diagrams showing the message flow of DHCP messages issued by the CPE **18** and the cable modem **16** in the system shown in FIG. 2. FIGs. 4A-4E are described below as events that occur during a simultaneous re-boot of the CPE **18** and of the cable modem **16**. One of ordinary skill in the art will appreciate, however, that the process illustrated by FIGs. 4A-4E advantageously insures DHCP connectivity by the CPE **18** in any situation in which it is sought before the cable modem **16** has achieved connectivity with the data network **28**.

Referring to FIG. 4A, during the initialization of the cable modem driver **160** (shown in FIG. 3), the DHCP client **100** in the CPE **18** issues a DHCP DISCOVER message **200a**. The DHCP DISCOVER message **200a** is communicated to the cable modem **16** for transmission to the data network **28**. The DHCP DISCOVER message **200a** is issued for the purpose of discovering the DHCP server **50** connected to the data network **28** that will provide the CPE **18** with an IP address. The cable modem **16** is also initializing and as part of its initialization, it issues a cable modem DHCP DISCOVER message **202a** to retrieve a cable modem IP address. As shown in FIG. 4A, the cable modem configuration parameters does not yet have the cable modem IP address **192a** and the other configuration parameters **192b**.

The cable modem driver **16** receives the CPE DHCP DISCOVER message **200a**. Because the cable modem **16** has not achieved connectivity with the data network **28**, the temporary DHCP server **140** receives the CPE DHCP DISCOVER message at **200b**. The

temporary DHCP server **140** includes the client temporary IP address **142a** and the lease time **142b**. The temporary DHCP server **140** responds by configuring a DHCP OFFER message **200c** for transmission by the cable modem driver **16** to the DHCP client **100** over **200d**. The DHCP OFFER message includes the temporary IP address and the lease time.

The DHCP client **100** receives the DHCP OFFER at **200d** and issues a DHCP REQUEST to accept the configuration parameters. The DHCP server **50** responds with a DHCP ACKNOWLEDGE. When the DHCP client **100** receives the DHCP ACKNOWLEDGE, the DHCP client **100** sets the configuration parameters for the CPE **18** at **200e**. The CPE IP address **194a** is set to the temporary IP address and the other configuration parameters **194b** includes the lease time. The temporary IP address **142a** received by the CPE **18** may not be used for communication over the data network **28** since it was not assigned by the DHCP server **50**. The cable modem **16** preferably filters any attempts by the CPE **18** to use the temporary IP address **142a**.

Referring to FIG. 4B, the time that the lease time provides for the assignment of the temporary IP address **142a** to the CPE **18** may expire many times before the cable modem **16** is able to connect to the data network **28**. Each time the lease time expires, the DHCP client **100** sends a request to renew the temporary IP address **142a** at **204a** in FIG. 4B. The cable modem **16** sends the request to the temporary DHCP server **140**, which determines whether the cable modem **16** has achieved connectivity with the data network **28**. If the cable modem **16** has not achieved connectivity with the data network **28**, the temporary DHCP server **140** sends a DHCP ACK message at **204c**. The DHCP client **100** receives the DHCP ACK message at **204d** and re-assigns the temporary IP address at **204e** with the lease time. The request to renew process shown in FIG. 4B may be repeated many times before a permanent IP address can be assigned to the CPE **18**.

Referring to FIG. 4C, in response to the DHCP DISCOVER message **202a** in FIG. 4A, the cable modem **16** receives a DHCP OFFER from the DHCP server **50** at **202b**. The DHCP OFFER message includes a cable modem IP address and other configuration parameters used by the cable modem **16** to communicate over the data network **28**. The cable modem **16** sets the cable modem IP address **192a** and the other

configuration parameters **192b** in a configuration parameter table. Once the cable modem **16** has received the cable modem IP address **192a** and its other configuration parameters **192b**, it may complete its initialization and registration process to achieve connectivity to the data network **28**.

Referring to FIG. 4D, although the cable modem **16** has achieved connectivity with the data network **28**, the DHCP client **100** in the CPE **18** continues to attempt to renew its temporary IP address **194a** at **204a**. The temporary DHCP server **140** receives the request at **206a**. Because the cable modem **16** has achieved connectivity with the data network **28** and therefore, access to the DHCP server **50**, the temporary DHCP server **140** denies the request using a DHCP NACK message at **206b**. The DHCP client **100** receives the DHCP NACK message at **206c** and determines that it no longer has a valid IP address.

Referring to FIG. 4E, the DHCP client **100** in the CPE **18**, sends a DHCP DISCOVER message at **200a** to obtain a new IP address. The cable modem **16** receives the message and transmits the message at **208a** over the data network **28**. The DHCP server **50** responds to the DHCP DISCOVER message at **208b** with a DHCP OFFER message containing a legitimate CPE IP address from its database of IP addresses **196**. The cable modem **16** sends the DHCP OFFER to the DHCP client **100** at **208c**. The DHCP client **100** issues a DHCP REQUEST to accept the configuration parameters. The DHCP server **50** responds with a DHCP ACKNOWLEDGE. When the DHCP client **100** receives the DHCP ACKNOWLEDGE, the DHCP client **100** assigns the configuration parameters including the CPE IP address at **208d**.

In a preferred embodiment, the parameters that the DHCP client **100** may receive include:

- IP address
- default gateway
- subnet mask
- domain name
- domain name server
- lease time

- binding time
- renewal time
- tftp filename
- tftp server address

These configuration parameters are described in RFC 2131. In a preferred embodiment, the lease time that may be provided in the DHCP OFFER message in FIG. 4E is longer than the lease time provided in the DHCP OFFER message in FIG. 4A.

While the invention has been described in conjunction with presently preferred embodiments of the invention, persons of skill in the art will appreciate that variations may be made without departure from the scope and spirit of the invention. For example, the use of the protocols, tools, operating systems and standards referenced above is merely by way of example. Any suitable protocol, tool, operating system or standard may be used in preferred embodiments of the present invention. In addition, the methods described in FIGs 4A-4E are described in the context of a data over cable system. However, the temporary configuration server may operate in any network connection that provides access to the data network **28**. This true scope and spirit is defined by the appended claims, interpreted in light of the foregoing.